Determination of Traces of Fissionable Materials using Delayed Neutron Activation Analysis

Detection and measurement of small traces of fissionable uranium and plutonium can be performed by delayed neutron activation analysis (DNAA). The method is intrinsically specific to nuclear fission, the sensitivity is excellent, and the procedure is simple, rapid, and readily automated for high throughput. Tiny traces of fissionable uranium or plutonium can be left behind whenever these materials are handled or transported. Using neutrons from the NIST research reactor, the delayed neutrons from fission in these traces can be used to detect and quantitate U and Pu in swipe samples with excellent speed, sensitivity, and specificity.

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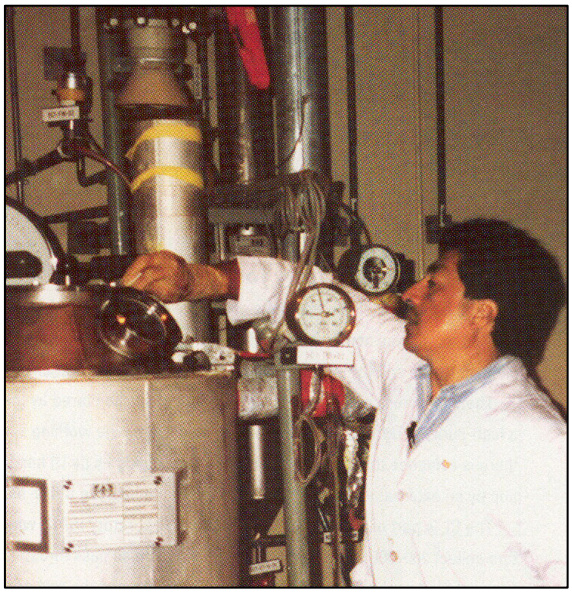
Delayed neutron activation analysis (DNAA) has been established at NIST for the measurement of small quantities of fissionable nuclides such as ^{235}U and ^{239}Pu. After a brief neutron irradiation, the sample is placed quickly into a neutron detector array and the neutron emission rate measured and compared with that of a standard. The method is well-tested, rapid, specific, matrix independent, nondestructive, and sensitive. The NIST system can detect less than one nanogram of either of these species, in less than 3 minutes per sample.

The neutron detection consists of ten pressurized ^{3}He proportional counters in a 30 cm x 30 cm cylindrical moderator of polyethylene, lined with 2 cm of lead to absorb gamma radiation. The existing pneumatic rabbit assembly controls the irradiation. After removal from the reactor, the sample is blown rapidly to the neutron detector through a polyethylene flight tube. The neutron emission rate is measured as a function of time, and the fissionable content is determined by comparison with a standard of known uranium content. Tests have shown that the system's response to gamma radiation and interferences from fast-neutron reactions on oxygen and thorium are negligible. Automation of the sample transfer sequence, now under way, will make the analysis more reproducible and less labor intensive.

Impact: With the completion and verification of the DNAA system, NIST has a readily accessible, rapid means of measuring traces of fissionable U and Pu in samples of forensic interest. In addition, the specificity and sensitivity of this method of analysis will be put to use in certifying trace uranium in Standard Reference Materials.

Future plans: It has been demonstrated elsewhere that ^{233}U, ^{235}U, and ^{239}Pu can be distinguished by the relative yields of delayed neutron precursors with different half-lives, and also of several fission products. We plan to add a gamma-ray detector into the neutron moderator to exploit this signature



As shown in the figure, an important tool in nuclear forensics is the collection and analysis of "swipe" samples at sites where materials of interest may be, or may have been at one time.